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ON THE EFFECTIVE TEMPERATURE OF ALPHA HERCULIS A.(U)
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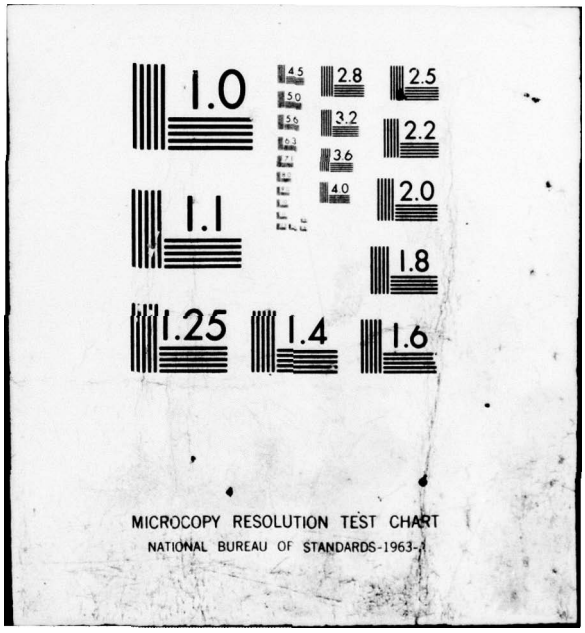
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ON THE EFFECTIVE TEMPERATURE OF α HERCULIS A

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ABSTRACT

Measurements of α Her A with the Amplitude Interferometer yield a uniform disk angular diameter of 0".058 ± 0".009. The fundamental effective temperature, 2450°K, obtained from this measurement is in good accord with those of luminous stars of neighboring spectral types, and differs markedly from previous determinations.

Subject Headings: stellar diameters - effective temperatures - α Her.

The coolest stars for which angular diameters have been obtained are α Her, o Ceti, and R Leo. These stars thus should form the calibration of the extreme low temperature end of the fundamental effective temperature-spectral type scale. In his classical discussion of the stellar temperature scale, Kuiper (1938) used the results for o Ceti (M6e variable; Keenan 1960) with reduced weight on account of the large variation in the parameters of that star. Kuiper did not include α Her A (M5II; Keenan 1960) in his discussion because of the preliminary nature of the angular diameter measurement (Pease 1931). Kuiper noted that α Her was the faintest star observed by Pease. More recent discussions of the effective temperature scale, for example those of Harris (1963) or Johnson (1964), also omit the α Her measurement from the fundamental data. The effective temperatures tabulated by Allen (1973) extend only to spectral type K5 for supergiants and type M0 for giants. Pettit and Nicholson (1928) used their fundamental radiometric measurements and the diameter measurements given by Pease (1931) to derive effective temperatures for late type luminous stars. They showed (see their Table VI) that the resulting effective temperatures depart from those calculated by assuming black body radiators. The departure of the effective temperature of α Her A (by $\sim$ 50%) from a black body is more than twice as large as the departures for other very cool stars measured by Pease.

We report here a new determination of the angular diameter of α Her A made with the University of Maryland Amplitude Interferometer (c.f. Currie, Knapp, and Liewer 1974; hereinafter CKL), as part of a program of angular diameter measurements of late-type giant stars which has been in progress since 1972. α Her was observed on six nights in the summer of 1973, using the 60- and 100-inch telescopes at Mount Wilson

and the 200-inch Hale telescope. The results reported here are based on an analysis of the data taken on four clear nights; the data taken on the remaining partially cloudy nights are being analyzed but the reduction is considerably more complicated. The results rely most heavily upon the 100-inch measurements. The measurement technique is summarized in CKL and is described at more length by Currie (1967) and Knapp (1974). The Amplitude Interferometer has been shown (CKL; Knapp, 1974) to produce measurements which are repeatable from night to night, given only clear weather and moderately good seeing.

As analysed by Knapp (1974) the average uniform disk diameters of α Her A were measured to be 0".053 ± 0".010 and 0".062 ± 0".007 at 5803 Å and 6328 Å, respectively. The errors give the total uncertainty, which is a combination of the internal error from the comparison of repeated measurements and the estimated external error due to possible systematic causes (c.f. CKL). None of the individual determinations with the Amplitude Interferometer on any of the nights at either wavelength gives a disk diameter for α Her A less than 0".048. We adopt the mean of the above average determinations for the uniform disk angular diameter of α Her A: 0".058 ± 0".009. This disk diameter is roughly a factor of two larger than those obtained in other measurements. These are 0".030 at 5750 Å by Pease (1931) and 0".031 ± 0".003 by Gezari, Labeyrie, and Stachnik (1972).

A set of data, consisting of the measurements of the fringe visibility at four aperture separations, takes about one hour of observing time for α Her. This set of data is then reduced to make a determination of the apparent angular diameter. These determinations of the diameters are then averaged in a weighted fashion, to produce the results quoted above. As an illustration of the Amplitude Interferometer data, we plot in Figure 1 the normalized visibilities from all of the runs against resolving power d/λ, where d is the interferometer aperture separation and λ is the wavelength. The

number of measurements averaged for each point varies from N = 6 to N = 2. The error bars in Figure 1 for $N \geq 4$ are standard deviations, and for $N < 4$ the error bars are enlarged when necessary to the values extrapolated from the cases of larger samples. The solid line in Figure 1 is the visibility function for a uniform disk of diameter 0".058. The dashed lines give the uniform disk visibility functions for diameters at the limits dictated by the uncertainty of $\pm$ 0".009, obtained above.

This angular diameter allows us to calculate an effective temperature for α Her A of 2450° $\pm$ 200°K, where the error is derived from the uncertainty in the angular diameter only.

To compare the effective temperature of α Her A with that of other stars, it is necessary to use the same method of calculation for each star. In order to maintain consistency we have chosen the set of effective temperatures given by Dyck, Lockwood and Capps (1974) and corrected their value of the effective temperature of α Her A by the square root of the ratio of their listed angular diameter to that measured by us.

Any correction to the effective temperature for limb darkening[1] made by Dyck *et al*. (1974) is not affected by our correction for diameter since we have used the ratio of diameters which are not corrected for limb darkening (uniform disk diameters).

We note the above value of the effective temperature of α Her A (M5.5) is intermediate between the fundamental effective temperatures of 3250°K for α Ori (M3) and 2050°K for R Leo (M8.4) and is equal to the effective temp of ο Ceti which was also M5.5 at the time of its measurement. These temperatures are from Dyck *et al*. (1974) as are the photometric spectral types.

By contrast, the effective temperature for α Her A using a diameter of 0".031 (Gezari et. al., 1972), which was measured at a different epoch, is 3350°K. The value of the effective temperature of α Her A based on the diameter obtained with the Amplitude Interferometer is in better accord with other late-type fundamental effective temperatures than those obtained from previous diameter measurements. A redetermination of the fundamental effective temperature scale using other late-type stars is planned as further diameter measurements are accumulated.

We would like to thank Dr. Horace W. Babcock, the Director of the Hale Observatories, for generous grants of observing time. We wish also to thank Dr. Arthur H. Vaughan and the members of the staffs of the Hale Observatories and of the California Institute of Technology for their assistance in the preparations for our observing. Dr. R. A. Bell critically read an earlier version of the manuscript, and made a number of valuable suggestions. This work was supported in part by NASA under grant NGR 21-002-301. The data reduction was largely carried out at the University of Maryland Computer Science Center with the support of NASA grant NsG 398.

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[1]The effect of plausible models of limb-darkening (c.f. Kuiper 1938; Knapp 1974) on the derived effective temperature is minor and is small compared to present uncertainties.

REFERENCES

Allen, C. W. 1973, Astrophysical Quantities (London: Athlone Press).

Currie, D. G., Knapp, S. L., and Liewer, K. M. 1974, Ap. J., 187, 131.

Currie, D. G. 1967, Woods Hole Summer Study on Synthetic Aperture Optics, Vol.2 (Washington: National Academy of Sciences-National Research Council), Appendix II.

Dyck, H. M., Lockwood, G. W., and Capps, R. W. 1974 Ap. J., 189, 89.

Gezari, D. Y., Labeyrie, A., and Stachnik, R. V. 1972, Ap. J. (Letters), 173, L1.

Harris, D. L. 1963, Ch. 14 in Basic Astronomical Data (ed. K. Aa. Strand), Vol. III in "Stars and Stellar Systems" (Chicago: University of Chicago Press).

Johnson, H. L. 1964, Bull. Ton. y Tac., 3, 305.

Keenan, P. C. 1960, Ch. 14 in Stellar Atmospheres (ed. J. L. Greenstein), Vol. VI in "Stars and Stellar Systems" (Chicago: University of Chicago Press).

Knapp, S. L. 1974, Ph. D. thesis, University of Maryland.

Kuiper, G. P. 1938, Ap. J., 88, 429.

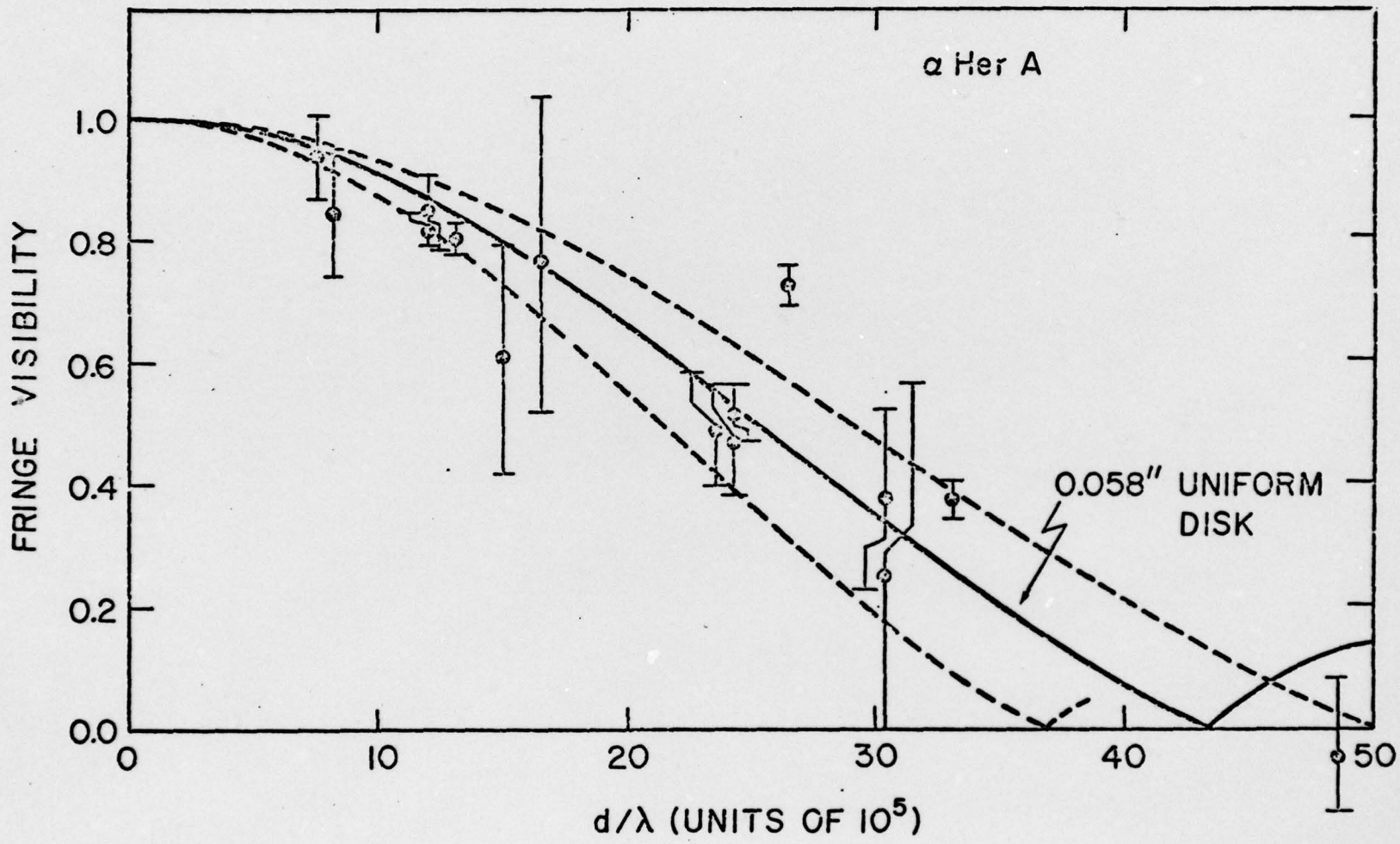
Pease, F. G. 1931, Ergebn. Exacten Naturwiss., 10, 84.

Pettit, E. and Nicholson, S. B. 1928, Ap. J., 68, 279.

Figure Caption

Figure 1

The relationship between the fringe visibility and the aperture separation, expressed in wavelengths, for α Her A.


α Her A
FRINGE VISIBILITY
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
d/λ (UNITS OF 10^5)
0.058" UNIFORM
DISK